Rapid Health-Based Method For Measuring Microbial Indicators Of Recreational Water Quality

Kristen Brenner[1], Rebecca Calderon[2], Alfred Dufour[1], Richard Haugland[1], Elizabeth Sams[2], Timothy Wade[2], Shawn Siefring[1], Michael Beach[3]

- [1]U.S. Environmental Protection Agency (U. S. EPA)/Office of Research and Development (ORD)/National Exposure Research Laboratory (NERL)/Cincinnati, OH
- [2]U.S. EPA/ORD/National Health and Environmental Effects Laboratory (NHEERL)/Research Triangle Park, NC
- [3]Centers for Disease Control and Prevention, Atlanta, GA

The Problem

Because the currently approved cultural methods for monitoring indicator bacteria in recreational water require 24 hours to produce results, the public may be exposed to potentially contaminated water before the water has been identified as hazardous. This project was initiated to evaluate a rapid health-based method that could obtain results the same day the water was collected. Use of a rapid method will allow beach managers and public health officials to alert the public about potential health hazards in a timely manner (≤ 2 hours), thereby reducing illness from recreational water use.

Research Methods

The beach epidemiological water study [National Epidemiological and Environmental Assessment of Recreational (NEEAR) Water Study] consisted of (1) a water quality study of beach waters using a rapid, same-day method, the Quantitative Polymerase Chain Reaction (QPCR), to determine *Enterococcus* concentrations and (2) a swimmer health survey of illness outcomes after exposure of the swimmers to the water.

NEEAR Study Design

1. Two methods: QPCR and EPA Method 1600.
2. Four freshwater Great Lakes beaches.
3. Six sample locations (or nine at Huntington Beach).
4. Three sample visits per day at 8 AM, 11 AM, and 3 PM.
5. Saturdays, Sundays, and holidays.
6. 8-12 weekends per beach.
7. Concurrent survey of swimming-associated illnesses at each beach.
8. Ancillary measurements for each water sample, including beach, water, and weather conditions, pH, and turbidity.

Beach Sites

The NEEAR Water Study was conducted in 2003 and 2004 at four freshwater Great Lakes beaches that were influenced by point sources of wastewater.

1. West Beach, Indiana Dunes National Lakeshore, Porter, Indiana.
2. Huntington Beach, Bay Village, Ohio.
3. Washington Park Beach, Michigan City, Indiana.
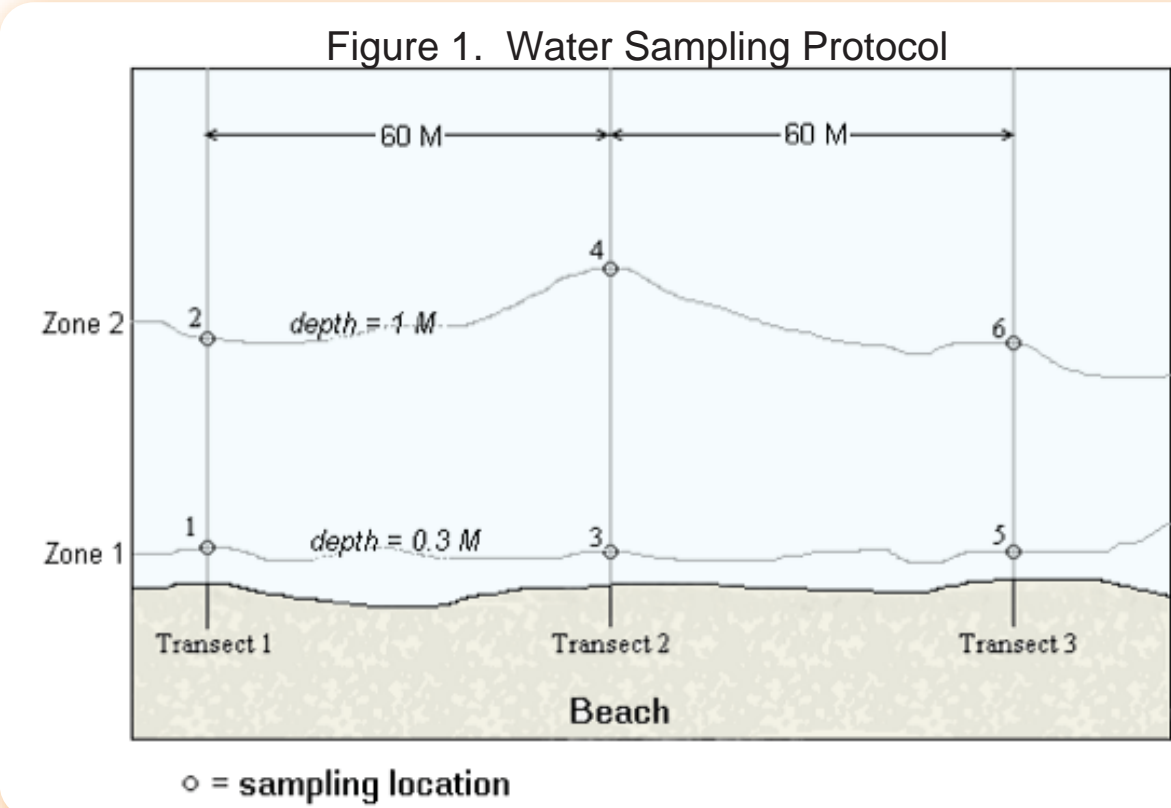4. Silver Beach, St. Joseph, Michigan.

○ 2003 Beach Sites
✷ 2004 Beach Sites

1. Water Quality Study and Rapid Method Evaluation (NERL)

Water Sample Collection:

Six water samples were collected three times a day at all beaches, except Huntington Beach, along each of three transects perpendicular to the beach shoreline, one in waist-high water (*i.e.*, 1 meter deep) and one in shin-high water (*i.e.*, 0.3 meter deep) (See Figure 1.), for a total of 18 samples per day. Because the rock piers/jetties at Huntington Beach prevented free circulation of water, three additional shin-high samples (9 samples three times a day, for a total of 27 samples per day) were collected at each visit using a modified sampling scheme to properly characterize the beach.

Figure 1. Water Sampling Protocol

60 M | 60 M

Zone 2 depth = 1 M

Zone 1 depth = 0.3 M

Transect 1 | Transect 2 | Transect 3
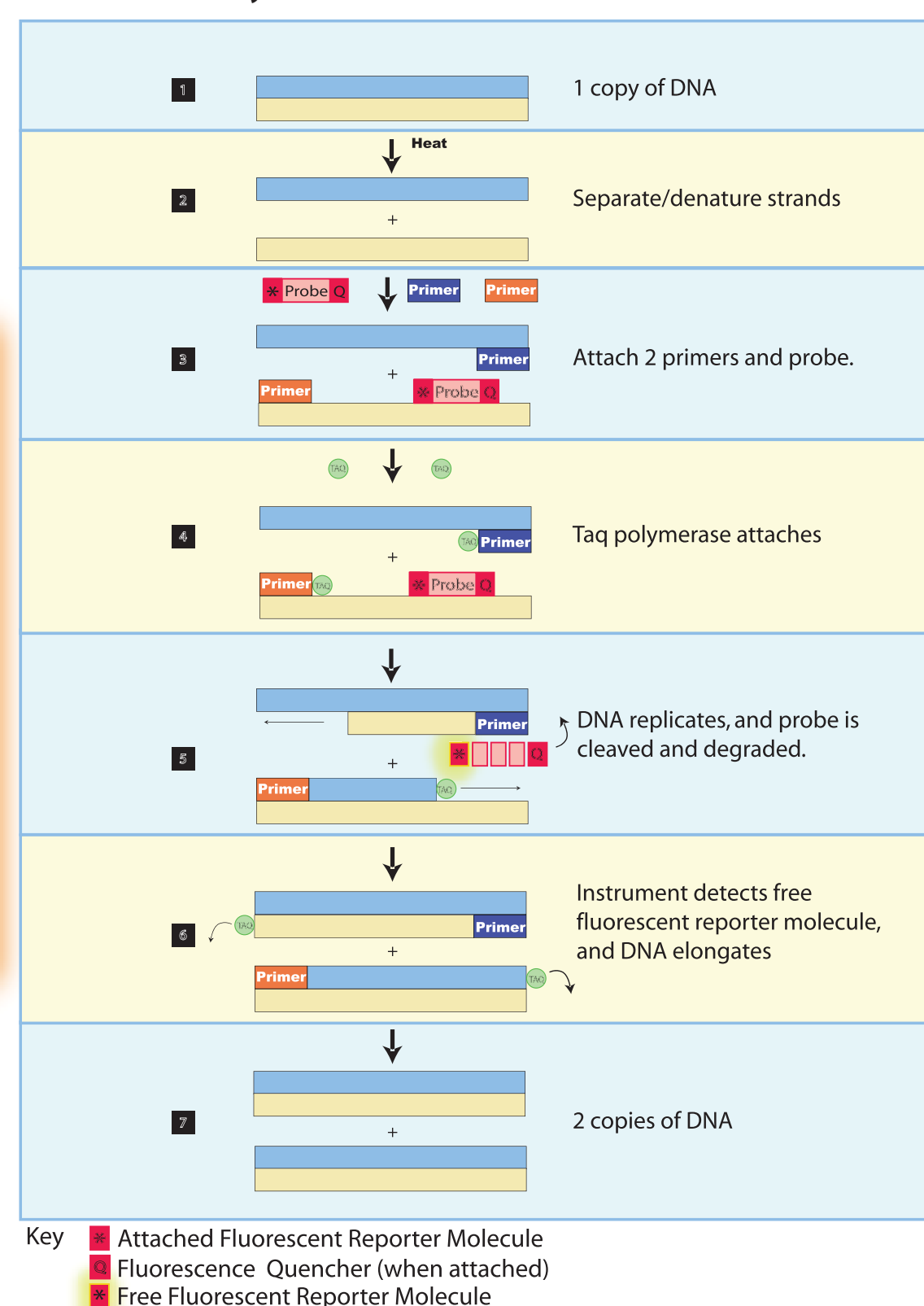
Beach

◇ = sampling location

Microbiological Methods:

- USEPA Method 1600 - The EPA-Approved Membrane Filter Method for the Detection of *Enterococci* in Recreational Water:
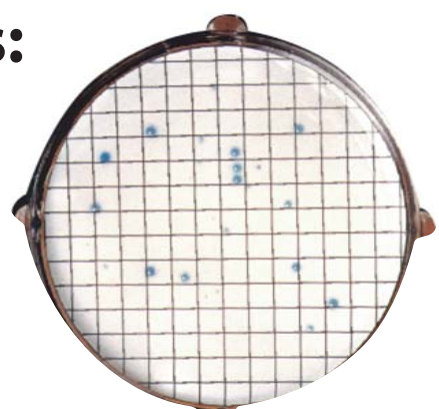
US EPA Method 1600

- Quantitative Polymerase Chain Reaction (QPCR) for the Same-Day (≤ 2 hours) Detection of *Enterococci*:

1. 1 copy of DNA
2. Heat → Separate/denature strands
3. Attach 2 primers and probe.
4. Taq polymerase attaches
5. DNA replicates, and probe is cleaved and degraded.
6. Instrument detects free fluorescent reporter molecule, and DNA elongates
7. 2 copies of DNA

Key: ■ Attached Fluorescent Reporter Molecule ■ Fluorescence Quencher (when attached) ■ Free Fluorescent Reporter Molecule

2. Swimmer Health Survey (NHEERL)

Swimmer Health Survey Outcomes:

Gastrointestinal Illness (GI) – defined as any of the following:
  a. Diarrhea – 3 or more loose stools in a 24-hour period.
  b. Vomiting, nausea, and stomachache.
  c. Impact on activity and either nausea or stomachache.
Upper Respiratory Illness (URI) - defined as any two of the following: sore throat, cough, runny nose, cold, fever.
Skin rash.
Eye ailment – eye infection or watery eye.
Earache.

Definitions:

Swimmer – a person who immersed his/her body in the water with or without head immersion.

Non-Swimmer – a person who did not wade, swim or play in the water.

Beach Interview · Part A
Enrollment Data Collected at participant location on beach Ⓐ

Beach Interview · Part B
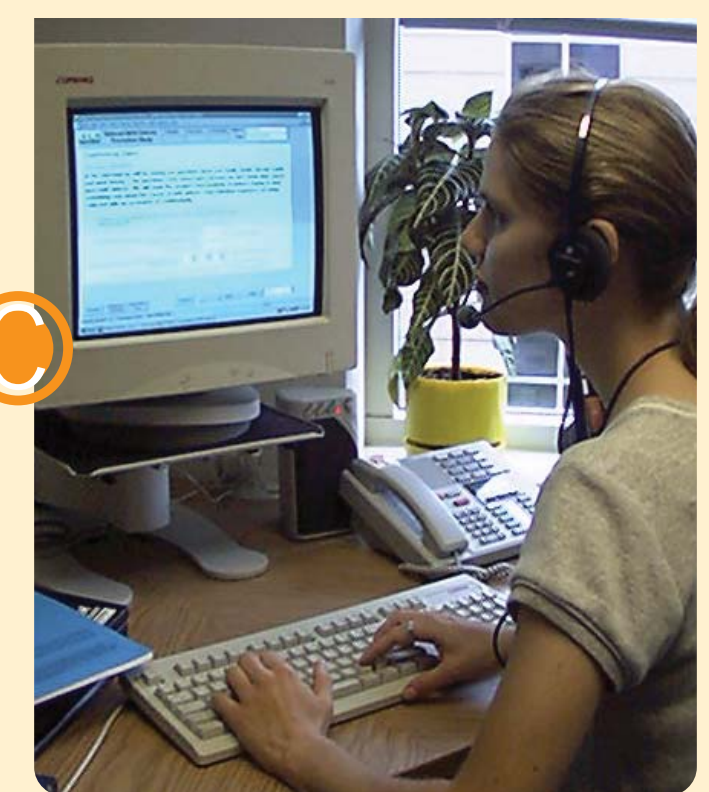Exposure Data Collected as participants leave beach Ⓑ
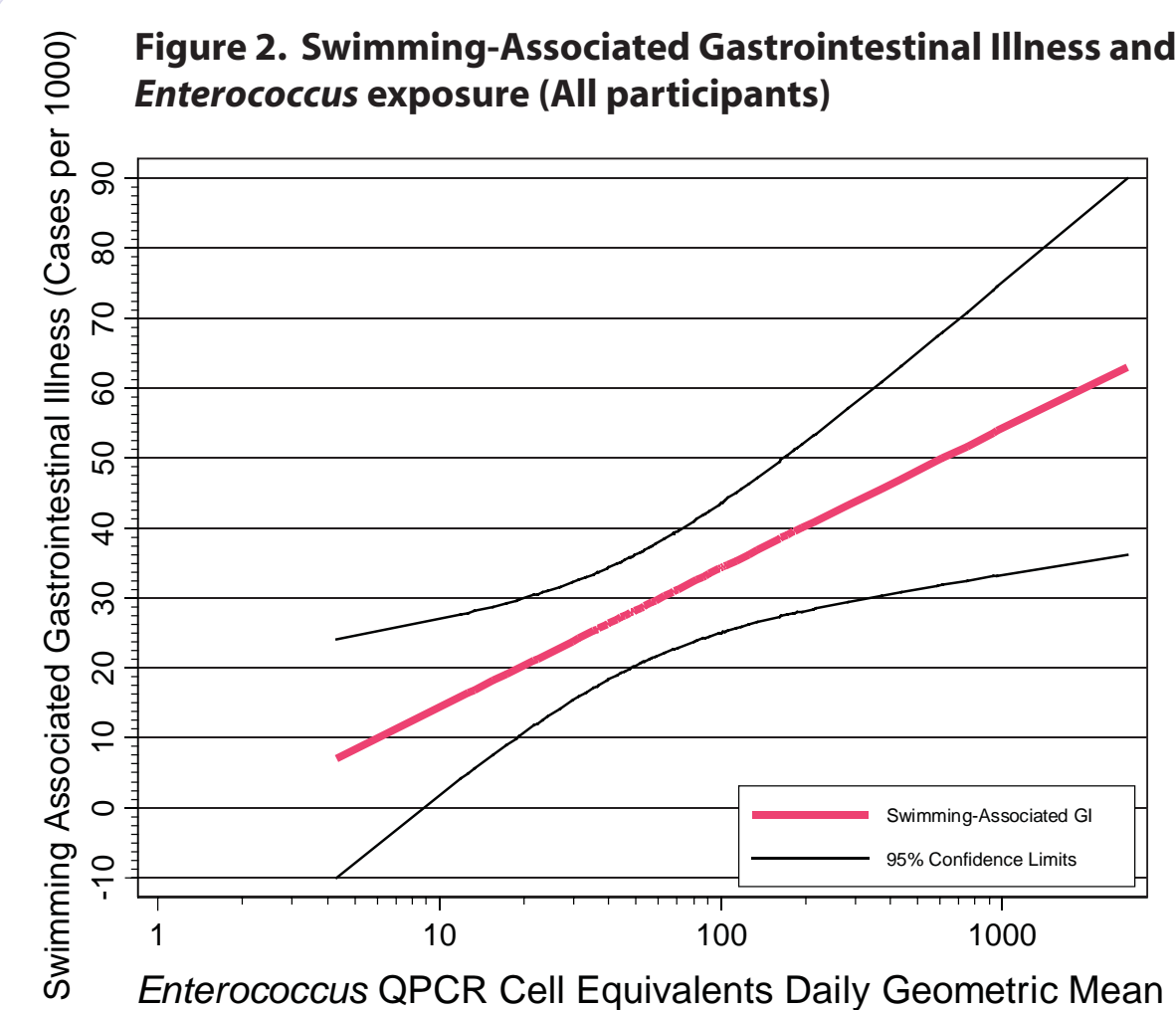
Phone Interview 10-12 days later
Health Data (Illness since swimming at beach) Ⓒ

Results

1. Results from the QPCR method were detected by the Smart Cycler Instrument (Cepheid) in "real-time" (*i.e.*, in ≤ 2 hours).
2. *Enterococci* concentrations, obtained using the QPCR method, were significantly correlated with swimming-associated gastroenteritis (*i.e.*, As the concentrations of *Enterococci* increased, the risk of gastroenteritis also increased.) (See Figure 2.).
3. Swimmers experienced more gastrointestinal illness, rashes, and earaches than non-swimmers.
4. The incidence of gastrointestinal illness was higher in children than in adults.
5. The 8 AM water sample analyses were predictive of illness the same day.

Figure 2. Swimming-Associated Gastrointestinal Illness and *Enterococcus* exposure (All participants)

Swimming Associated Gastrointestinal Illness (Cases per 1000)

Enterococcus QPCR Cell Equivalents Daily Geometric Mean

— Swimming-Associated GI
— 95% Confidence Limits

Conclusions

Use of the QPCR method, which is capable of producing "real time" results in ≤ 2 hours, will allow beach managers and public health officials to alert the public in a timely manner about potential health hazards at Great Lakes beaches, thereby reducing waterborne illness. The data from this research study will be used by the U. S. EPA Office of Water in their efforts to provide new health-based criteria and guidelines for recreational water quality.

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